LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

LLNL-TR-667296

LX-17-1 Creep: Spring Load-up Study

F. Gagliardi, S. Pease

February 12, 2015

Disclaimer

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

We performed a study on billet pressed LX-17-1, Holston lot HOL87G51009, to examine the effect of adding a spring into the load train of our compression creep system. This effort was undertaken to see whether we could reduce test-to-test scatter by better controlling the load-up rate of our compressive creep tests.

The test series consisted of seven tests. All of the samples were machined from an isostatically pressed billet of LX-17-1 into 0.5-in by 1.0-in long cylinders. The samples were broken into two groups: group 1 had four samples that were tested without a spring in the load train, while group 2 was the other three samples and they were tested with a 21-lb/in spring in place. The log fits to the creep portion of the data and the strain at early and late times were compared between the two groups to assess whether or not the addition of the spring improved test-to-test repeatability.

Figure 1 shows the strain versus time data for the group of specimens that was tested without a spring in the load train. The specimens were tested at 250-psi at a temperature of 50˚C. These test conditions were chosen because the low stress level should result in strain on the lower end of the possible spectrum. We chose this option because when the level of strain is low the signal to noise ratio is less favorable. We desired to see if the spring effect would standout above the scatter expected when the signal was of this magnitude.

Figure 2 shows the strain versus time data for the second group of samples. These samples were tested with the 21-lb/in spring in the load train. As with the first set, these samples also were tested at 250-psi with a test temperature of 50˚C.

The creep portion of the data for all tests were fit with a log curve and the coefficients, shown in Equation 1, were found for each test and tabulated in Table 1.

$$\text{strain} = a + b * \log(\text{time}) \quad (1)$$

Since the initial creep data does not behave logarithmically, the first 10,000-seconds of the data were removed and only the stress-time data between 10,000-seconds and 250,000-seconds were used for the log fit calculation. Examining the calculated log fit equations we saw that the *a* coefficient varied widely. The creep rate coefficient, *b*, was much more stable. For the tests conducted without the spring in place the average creep rate was -367.8, with a standard deviation of 6.4 (1.7%). In comparison, the average creep rate for the group tested with the spring was -350.4, with a standard deviation of 20.8 (5.9%). The combined average for all of the tests was -360.3, with a standard deviation of 15.8 (4.4%). The creep rate log fit coefficient *b* does not indicate that the addition of the spring improves the test-to-test repeatability.

Next, using the strain at 100-seconds to compare the two groups, we see that the group tested without the spring had -759-µstrain, with a standard deviation of 76.8-µstrain (10%). The group tested with the spring had an average of -812.7-µstrain, with a standard deviation of 21.6-µstrain (2.7%). The combined average for all of the tests at 100-seconds was -782-µstrain with a standard deviation of 62.7-µstrain (8%). Using the early-test strain metric, we see that the spring tests have considerably less scatter than the tests run without the spring.

Lastly, looking at the strain at 250,000-seconds, we see that the group of four samples tested without the spring had an average of -1760-µstrain, with a standard deviation of 83.2-µstrain (4.7%). The group of three samples tested with the spring had an average strain of -1783-µstrain at 250,000-seconds, with a standard deviation of 86-µstrain (4.8%). The combined average for all seven tests was -1769.4-µstrain, with a standard deviation of 77.9-µstrain (4.4%). The late-test strain value does not show any improvement for the samples tested with the spring versus those tested without the spring.

Taking all of the data together, we see that the addition of the spring does not uniformly affect the test-to-test repeatability for creep tests of LX-17-1 tested at 250-psi and 50˚C in a positive way. The spread in the creep rate log coefficient *b* is actually worse for the samples tested with the spring loadup. The initial loadup strain seems to be improved by the addition of the spring but the late time strain does not show any improvement compared to data from the tests performed without using the spring. This study has shown us that compressive creep test-to-test repeatability issues are not solved by simply controlling the initial loadup better.

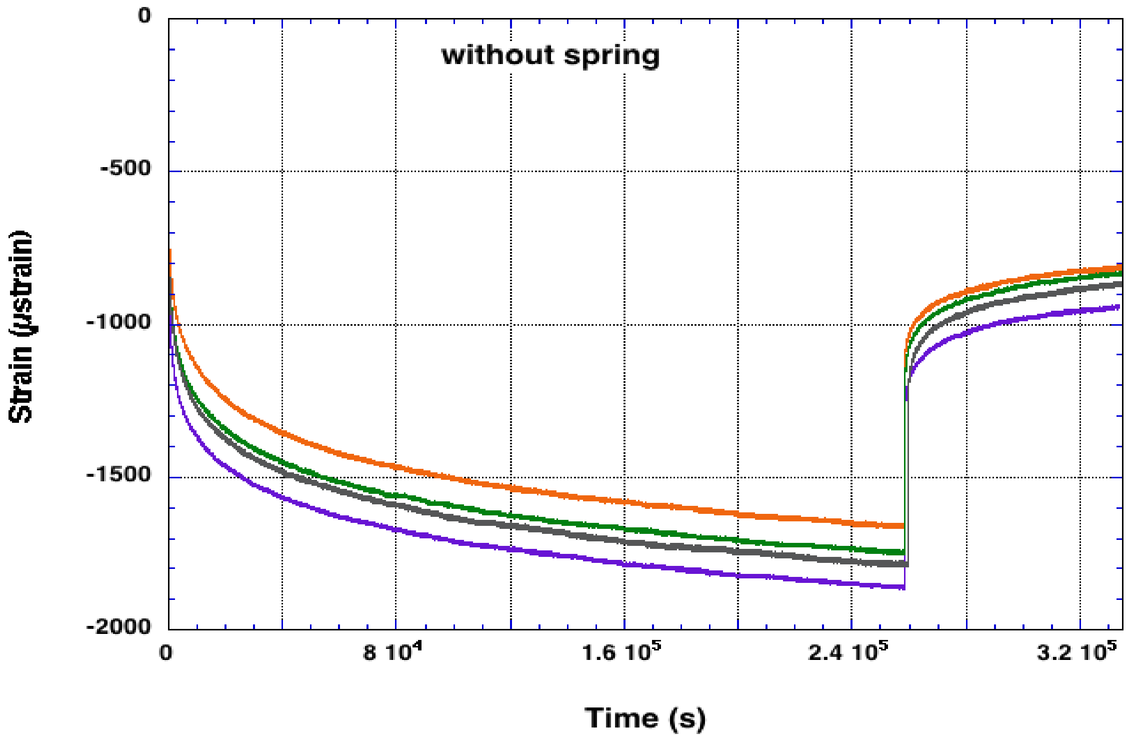

Figure 1. Strain versus time compressive creep plot for the group of LX-17-1 samples that were tested using the historical loading technique without a spring in the load train. Four tests were conducted with samples experiencing 250-psi of axial stress at a test temperature of 50˚C. Samples were under load for ~3 days and allowed to recover after unload for about a day.

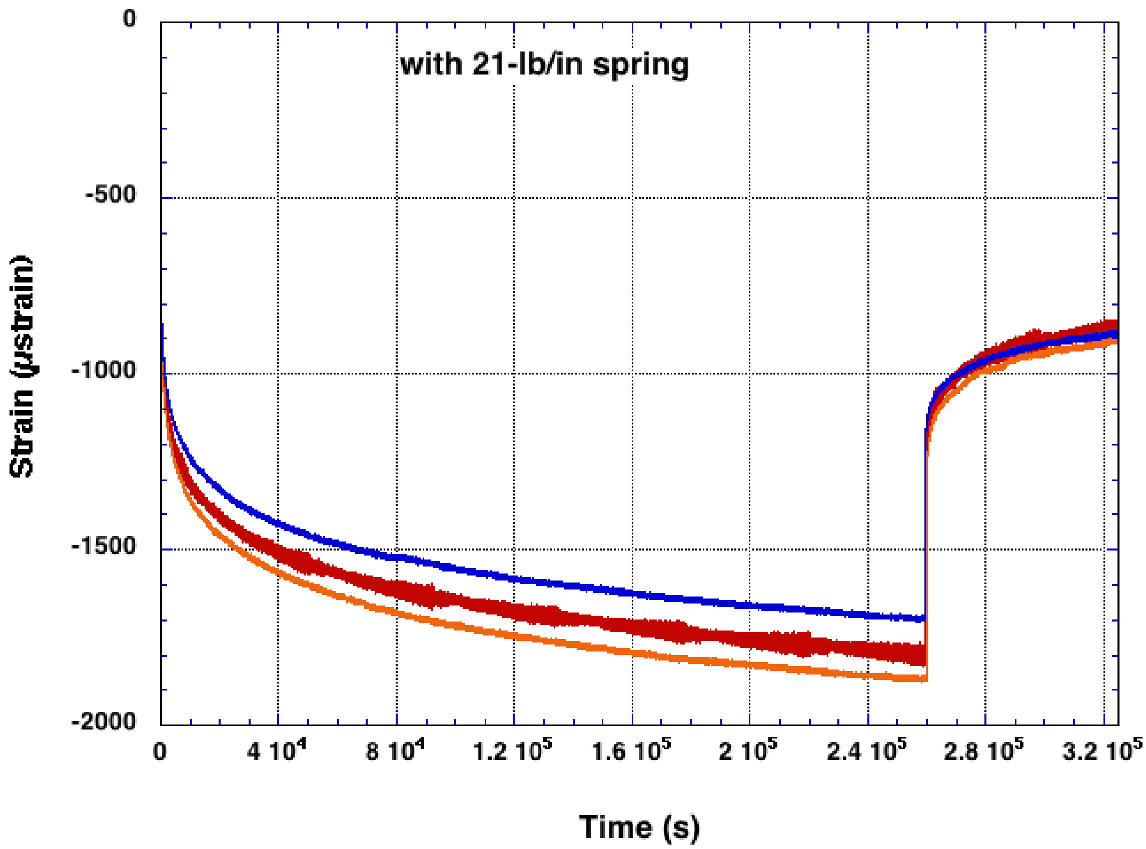

Figure 2. Strain versus time compressive creep plot for the second group of LX-17-1 samples that were tested, this time using a 21-lb/in spring in the load train. Three tests were conducted with samples experiencing 250-psi of axial stress at a test temperature of 50˚C. Samples were under load for ~3 days and allowed to recover after unload for about a day.

Table 1. Summary table showing the log fit coefficients to all of the creep curves acquired during this study, as well as the individual strain values near the beginning and end of the creep phase of the tests.

	Log Fit Coefficients (trimming first 10,000s)		**Strain at 100s**	**Strain at 250000s**
	a	***b***		
No spring				
1	70.47	-365.1	-854	-1857
2	364.47	-374.1	-666	-1657
3	203.96	-360.1	-762	-1743
7	227.01	-371.8	-754	-1781
Avg.	216.5	-367.8	-759.0	-1759.5
Std Dev.	120.4	6.4	76.8	83.2
with 21-lb/in Spring				
21	104.09	-350.6	-815	-1793
22	139.71	-371.18	-833	-1863
23	89.59	-329.5	-790	-1692
Avg.	111.1	-350.4	-812.7	-1782.7
Std Dev.	25.8	20.8	21.6	86.0
Combined Both Groups				
Avg.	171.3	-360.3	-782.0	-1769.4
Std Dev.	103.2	15.8	62.7	77.9